MST Program Plans

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Budget Planning Meeting

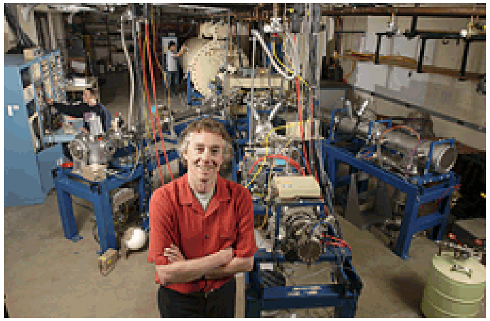
March, 2004

But first,

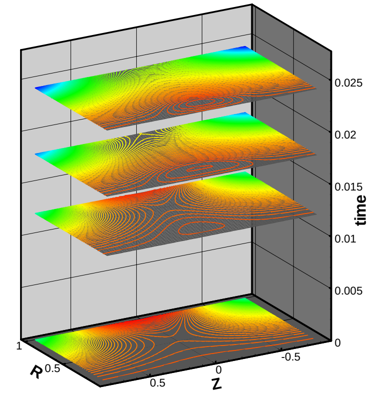
An Institutional Overview

The University of Wisconsin Fusion Science Program

DIONYSOS accelerator: plasma-materials interactions



Center for Plasma Theory and Computation



Wisc Shock Tube Experiment

PEGASUS Spherical Torus

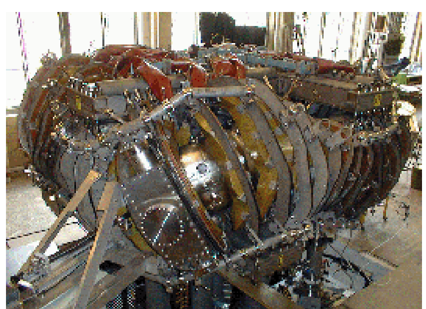
Institutional coverage of a large range of fusion science and technology issues

Fusion Technology Institute

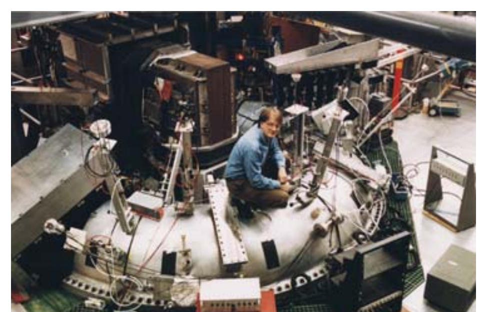
Collaborations on national experiments:

Theory and experiment

DIII-D, C-mod, Z



HSX Stellarator



MST Reversed Field Pinch

Also:

Tokamak turbulence experiments

Wall stabilization & dynamo experiments

NSF Physics Frontier Center

Fusion Research Coordination at Wisconsin

- Sharing of equipment, staff, graduate students
- Joint seminars and lots of cross-talk
- Joint plasma/fusion course development
- Campus-wide town meetings and fusion retreats
- Coordinated representation to Congress etc

Pegasus ST experiment rebuild and reconfiguration in final stage

Fall-Winter 02-03

Winter 03-04

- **Lab expanded and reconfigured**
- **Upgrades installed**
- **Subsystem testing in progress**

Outline for MST Plans

- Overall goals
- NSF Physics Frontier Center - relation to MST
- Major tasks
- FY 06 budget cases: decrement, level, planning

MST Program Goals

- Advance specific fusion physics issues
- Advance the RFP reactor configuration
- Investigate links to astrophysics

Major MST Physics Goals

- Discover lower limit to magnetic transport
- Discover role of electrostatic transport
- Determine beta limit
- Uncover physics of magnetic self-organization, and links to astrophysics

RFP configuration goals for MST

Establish sustained, good confinement

or

Establish an attractive pulsed reactor scenario

MST Strongly linked to two IPPA Goals

1. General understanding

   turbulent transport, macrostability, wave-particle interactions, general science

2. Innovative magnetic confinement configurations

MST contributes moderately to other two IPPA goals

3. Burning plasmas (and ITER)

   fast particle effects in RFP

   (and resistive wall instabilities, flow generation)

4. Technology

   RF antennas, pellets, neutral beam sources,

   in-situ boronization…

Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas

- Initiated September, 03
- An NSF Physics Frontier Center
- Goal: advance physics of MSO common to lab and astrophysics, establish links between the two communities
- Teams fusion physicists and astrophysicists (about evenly distributed)

Who

- 4 experiments (MST, MRX, SSPX, SSX)

- University of Wisconsin

  Princeton University

  University of Chicago

  SAIC

  Swarthmore College

  LLNL

- 24 initial co-investigators

  ~ another ~ 20 postdocs, students…..

Relation to DOE MST Work

- Strongly complementary and cross-fertilizing
- Enhances progress in fusion goals
- Enlarges scientific impact of MST results
- Great fusion outreach

- and, a very large challenge

The Center is a partnership between NSF and OFES

- Overlapping scientific goals

- OFES supports facilities, codes

- Success predicated on strong OFES support of base MST proof-of-principle program

Budget

- NSF $2.25M/yr for five years
  (~$1.5M at Wisconsin,
  ~ $0.7M for MST)

- DOE ~$0.4M to PPPL
  ~$0.1M to LLNL
  all facility and base program support

Major MST Tasks

(from budget viewpoint)

- Current drive and heating
  - Develop and apply to RFP
  - For confinement improvement, sustainment, beta limits, scaling

- Diagnostics
  - For equilibrium measurements (transport, flow….)
  - For fluctuations (magnetic and electrostatic)

Current drive and heating

- Lower hybrid wave injection
- Electron Bernstein Wave injection
- Oscillating field current drive
  (ac helicity injection)
- Neutral beam injection
- (pellet injection)

Status in FY 04

- Current drive and heating
  - Staged development, beginning at low power
  - Good progress in all systems
  - Will select for high power pending results and funds

- Diagnostics
  - Good equilibrium/transport diagnostics
  - Advanced fluctuation diagnostics developed and developing
  - Diagnostic set not fully utilized for lack of staff

Facility Upgrades in FY 04

Planned shutdown from 6/03 - 12/03

Expanded experimental area, built FIR room, fences, safety locks

Installed field error feedback correction coils

Drilled holes for LH antenna, NBI, pellet injection

Current drive and heating - outlook

Lower hybrid waves


Status: Antenna successful at 50 kW,

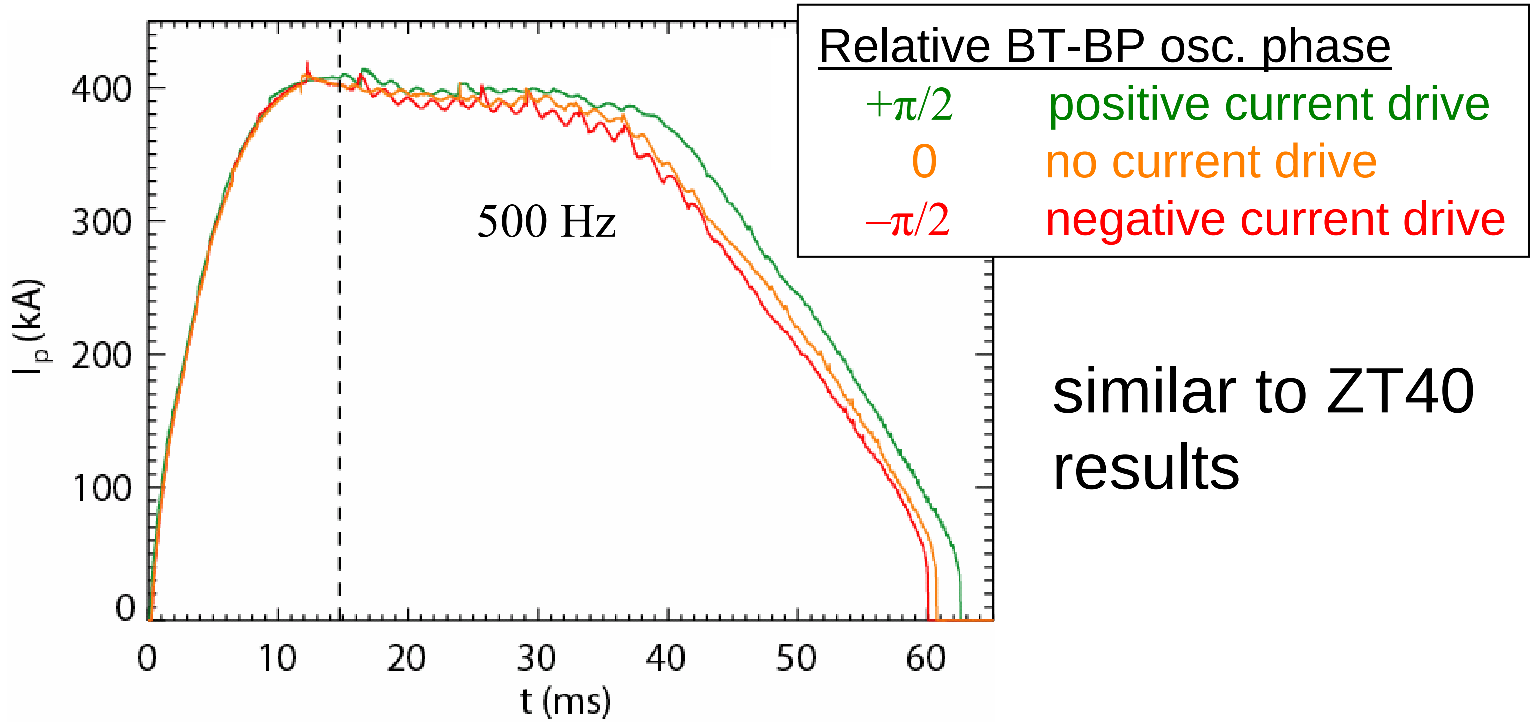
200 kW antenna being designed

Electron Bernstein Wave injection

Status: emission and low power coupling successful,

~ 100 kW tests FY 04

Oscillating Field Current Drive

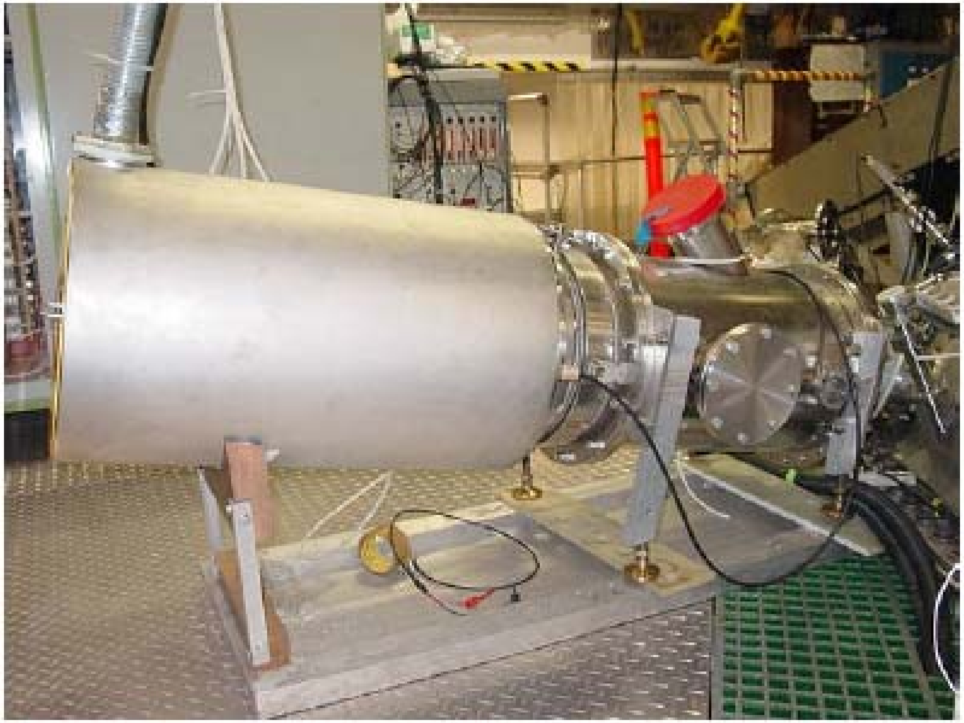


similar to ZT40 results

FY04: repeat at 250 Hz

FY04-05: new, higher power oscillators

Neutral beam injection



Novosibirsk

Status: two 150 kW diagnostic beams operate routinely

1.5 MW, 1.5 ms heating beam beginning FY 04

Pellet Injection

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

ORNL

Status: intriguing physics results with 2 barrels,

2 more barrels in FY 04

Planned Advances in Major Diagnostics

Ions

CHERS: Extend to fluctuations (temperature, velocity)

Electrons

Thomson scattering: commission multi-point
develop fast TS

Magnetic field fluctuations:

Laser Faraday rotation: increase sensitivity,
add tangential view

motional Stark effect: increase time coverage

Electric field fluctuations:

Heavy ion beam probe: Increase sensitivity

FY 06 decrement case

- Develop one CD/heating auxiliary system (RF or NBI)

- Perform higher power test of OFCD

- Further optimize inductive current profile control, with single shot confinement measurements

- Perform new fluctuation and transport measurements with fast CHERS, laser polarimetry, MSE, HIBP

- Connect MST results to plasma astrophysics

FY 06 Level Case - addition

In addition to decrement case,

- Begin major next step in RF or NBI
  (depending on FY 05 results,
  e.g., several hundred kW RF curr.drive test)

- Add engineer for fuller facility utilization

- Begin construction of programable power supply, for voltage and current profile control for improved confinemennt

FY 06 program planning case

- Advance to PoP program
- Increase facility utilization
- Develop critical auxiliary systems

MST Utilization

	Run Weeks	
Type of run	Appropriate Utilization	FY 05 Utilization
Full diagnostic set	16	5
Reduced diagnostic set	14	25
Instrument development	15	15

Program Planning Case - New Tasks

- Upgrade of either LH or EBW to 1 MW
- Upgrade neutral beam to higher power or longer pulse
- Add engineers and physicists for full facility utilization
- Continue construction of programmable power supply for loop voltage control
- Upgrade MSE for fluctuations
- Construct multi-point CHERS system
- Design, begin construction of fast Thomson for electron dynamics

MST Collaborations

- **UCLA - FIR interferometry/polarimetry**
- **RPI - Heavy ion beam probe**
- **Novosibirsk - neutral beam diagnostics and heating, MSE on GDT**
- **ORNL - pellet injection**
- **University of Texas - mode braking theory**
- **SAIC - MHD computation**
- **RFX, Italy - SXR, data analysis**
- **TPE-RX, Japan - PPCD expts**
- **T2, Stockholm - PPCD expts**
- **University of Strathclyde - Atomic data modeling**
- **U. Chicago - Center**
- **Princeton - Center**
- **Swarthmore - Center**
- **LLNL - Center**
- **Pegasus, HSX - Thom scat, HXR detection,**
- **Astronomy Dept - Center**

Theoretical RFP Research at Wisconsin

- Control techniques
  - 3D Single fluid modeling of inductive control (OFCD, PPCD)
  - RF studies (EBW, ICRH, ponderomotive stabilization)
  - Effects of fast particles
- Finite pressure effects on fluctuations and transport
  - 3D single fluid, nonlinear studies
  - coupling between large-scale and small-scale fluctuations
- Two-fluid effects on fluctuations and transport
  - Quasilinear calculations of dynamo
  - NIMROD development
- RFP turbulence
  - Effects of shear flow
  - self-consistency constraints

Severe underutilization of codes due to staff shortage

Summary

MST is well-poised to

- Advance the RFP fusion configuration to full proof-of-principle investigation

- Advance fusion plasma physics associated with self-organization

- Forge links to astrophysics

MST Staff Levels (FTEs)

	FY 04 Approp	FY 05 Request	FY 06 -10%	FY 06 Level	FY 06 Plan
Scientists	9	10	9	10	13
Engineers	8	8	8	8	10
Technicians	3	6	5	5	7
Admin	1	1.5	1.5	1.5	1.5
Professors	1.5	1.5	1.5	1.5	1.5
Postdocs	3	2	2	2	5
Grad Students	12	12	12	12	12

Oscillating Field Current Drive

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Status: low current tests underway; physics studies

1 MW operation begins FY 04

MST Budget Summary

(funding in $M)

	FY 04 Approp	FY 05 Request	FY 06 -10%	FY 06 Level	FY 06 Plan
Research Operations	3.1	3.8	3.7	4.1	5.6
Facility Operations	1.4	1.4	1.3	1.3	2.0
Research Collab.	0.5	0.9	0.4	0.6	1.0
Educational Outreach	0.05	0.05	0.05	0.05	0.05
Total	5.1	6.1	5.4	6.1	8.6

Topics

- Angular momentum transport
- Dynamo
- Reconnection
- Ion heating
- Magnetic chaos and transport
- Magnetic helicity conservation/transport